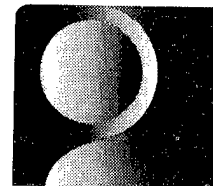
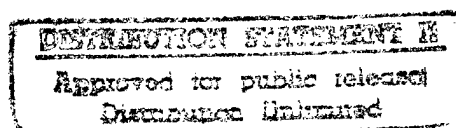


# ENERGY SURVEY OF ARMY DINING FACILITIES FORT BRAGG, NC



## EXECUTIVE SUMMARY

Contract #DACA21-86-C-0059  
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Final Report Submitted to:

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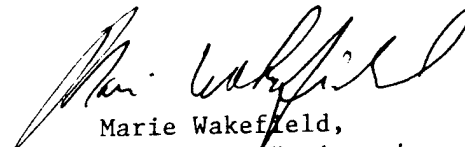


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## TABLE OF CONTENTS, EXECUTIVE SUMMARY

### Page

1.1	Introduction	1
1.2	General Description of the Facilities	3
1.3	Present Energy Consumption	4
1.4	Energy Conservation Analysis	4
1.5	Energy Cost and Savings	20
1.6	Projects Developed	20

### List of Figures

1-1	Total Annual Energy Consumption of Detailed Buildings	5
1-2	Calculated Annual Energy Cost of Detailed Buildings 1987	6
1-3	Energy Consumption Before and After for Detailed Buildings	23
1-4	Energy Cost Before and After for Detailed Buildings	24
1-5	Energy Cost Before and After for All Buildings	27

### List of Tables

1-1	List of Dining Facilities Audited	2
1-2	Estimated Building Energy Consumption and Cost	7
1-3	Sample ECO Checklist	8
1-4	Order of Computer Runs to Account for Interaction	14
1-5	Recommended ECOs, Ranked by SIR, All Buildings	15
1-6	Typical ECOs Not Recommended	20
1-7	Recommended ECOs by Category	21
1-8	Total Energy Cost and Consumption, Before and After Conservation (Detailed Buildings)	22
1-9	Energy Summary Data, Detailed Buildings	25
1-10	Extrapolated Energy Data, Walk-thru Buildings	26
1-11	Project Summary Totals	29

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## EXECUTIVE SUMMARY

### 1. Introduction

#### 1.1 Scope of Work

IES Engineers was contracted by the Savannah District of the US Army Corps of Engineers in July 1986 to perform a complete energy audit and analysis of forty-three dining facilities at Fort Bragg, North Carolina. The essential elements of the Scope of Work (SOW) are listed below. The majority of the buildings are permanent structures with a remaining useful life of over 25 years. Five of the buildings are temporary structures which are expected to remain in use for at least ten years.

BRIEF DESCRIPTION OF WORK: The Architect-Engineer (AE) shall:

1. Perform a complete energy Audit and Analysis of the dining facilities.
2. Identify all Energy Conservation Opportunities (ECOs) including low cost/no cost ECOs and perform complete evaluations of each.
3. Prepare programming documentation [DD 1391, Life Cycle Cost Analysis Summary Sheet with backup calculations and Project Development Brochure (PDB)] for any Energy Conservation Investment Program (ECIP) projects.
4. Prepare implementation documentation for all justifiable energy conservation opportunities.
5. List and prioritize all recommended Energy Conservation Opportunities.
6. Prepare a comprehensive report which will document the work accomplished, the results and recommendations.

The project consisted of detailed audits of twenty dining facilities and "walk-through" audits of the remaining twenty-three buildings. The buildings are listed by number in Table 1-1. Per the SOW, the Building Loads Analysis and Systems Thermodynamics (BLAST) computer program was used to simulate existing energy consumption and to evaluate energy conservation opportunities (ECOs) in the buildings receiving detailed audits. "Walk-through" audits were then performed on the remaining buildings in order to determine which of the previously identified ECOs could be duplicated.

In addition to the energy audits, the SOW also called for the testing of solar domestic hot water systems in buildings C-4122 and H-5718, and ventilation studies in all of the "C" buildings.

Table 1-1. List of Dining Facilities Audited

Buildings Included in Detailed Audit

Building	Sq ft	Building	Sq ft
C-4122	4,850	O-9013	4,800
C-4422	4,850	P-3042	7,857
C-6432	4,850	I-1242	3,168
C-8344	4,850	4-1437	7,500
C-8750	5,050	A-3275	5,608
C-9349	5,050	AT-4622	2,800
C-7236	4,850	AT-4632	2,800
D-2626	11,313	AT-4686	2,800
D-3404	9,346	MT-6115	2,375
H-5718	14,920	8T-3849	13,400

Buildings Receiving Walk-through Audits

Building	Sq ft	Building	Sq ft
C-3020	4,850	C-7433	4,850
C-3027	4,850	C-7634	4,850
C-3321	4,850	C-8339	4,850
C-4120	4,850	C-8541	4,850
C-4125	4,850	C-6726	4,850
C-4424	4,850	C-8438	4,850
C-4426	4,850	D-2105	11,313
C-4428	4,850	D-3039	11,313
C-5528	4,850	D-3055	11,313
C-5725	4,850	H-4842	14,920
C-6525	4,850	2-1105	3,168
		2-1138	3,168

## 1.2 General Description of the Facilities

Refer to Table 1-1 for a listing of all of the facilities. The "C area" buildings (buildings with the C prefix) are all similar concrete block structures consisting of a dining facility connected to a three story barracks. The barracks portion of each building was not included in the SOW of this study. The buildings are of two types; type 64 and type 121, with the only difference being slight variations in the floor plan.

The "D" buildings are dining facilities serving the "D area barracks". The barracks portion of each building was not included in the SOW of this study. All of the buildings are identical brick and block with the exception of D-3404. The floor plan and interior equipment of building D-3404 is slightly different from the other buildings.

Buildings H-4842 and H-5718 are relatively new dining facilities. The two buildings are similar brick and block buildings with slight variations in floor plans.

Building O-9013 is a prefabricated metal building which serves as a classroom and dining facility at the Mott Lake Training Center. The classroom portion of the building was not included in the SOW of this study.

Building P-3042 is a concrete block structure which houses a warehouse and dining facility for Simmons Army Airfield. The warehouse portion of the building was not included in the SOW of this study.

Buildings 1-1242, 2-1105, and 2-1138 are three story brick and block structures which serve as military police barracks. Each building houses a kitchen and dining facility on the ground floor. The SOW of this study included only the dining area portion of the building.

Building 4-1437 is a relatively new brick and block structure, half of which serves as a dining facility and the remaining half as storage and offices. The storage and offices are not part of the dining facility and were not included in the SOW of this study.

Buildings AT-4622, AT-4632, and AT-4686 are identical temporary wood frame dining facilities. The buildings have recently been covered with wall insulation and metal siding. Building MT-6115 is similar to these buildings with the only difference being a slight variation in size and the absence of new insulation and metal siding.

Building 8T-3849 is a large temporary wood frame structure serving as a dining facility. One dining room wing of the structure is currently used only periodically as a classroom, but was surveyed under this contract.

### 1.3 Present Energy Consumption

#### 1.3.1 Total Annual Energy Used

The total estimated energy consumption of the detailed buildings audited, as predicted by the BLAST computer model is shown in Figure 1-1. The total energy cost including demand charges is estimated at \$495,716. This assumes completion of all planned or ongoing projects. Figure 1-2 shows the total energy cost by fuel type.

#### 1.3.2 Energy Consumption by Building

Table 1-2 lists the energy consumption and cost by fuel type for all detailed buildings audited. These costs include electric demand costs.

### 1.4 Energy Conservation Analysis

#### 1.4.1 ECOs Investigated

All of the ECOs shown in the sample checklist (Table 1-3) on the following pages were investigated for each building in the SOW. Similar checklists for each building appear in the respective chapter for that building. A "Yes" means that the ECO seemed feasible in the field and was considered further. All those marked "Yes" are described in this report, although after further analysis some resulted in not being recommended. A "No" on the checklist indicates that the ECO was unfeasible as explained. A comparison of the SOW checklist and each of the building lists will show that many additional ECOs were investigated.

All of the ECOs were evaluated relative to the base case building simulations on BLAST. The BLAST runs were run interactively, i.e., assuming implementation of previously analyzed ECOs. The order of the BLAST runs is shown in Table 1-4. This order is based on the assumption that ECO's which will reduce the load on the HVAC equipment should be implemented before HVAC ECO's are implemented.

#### 1.4.2 ECOs Recommended

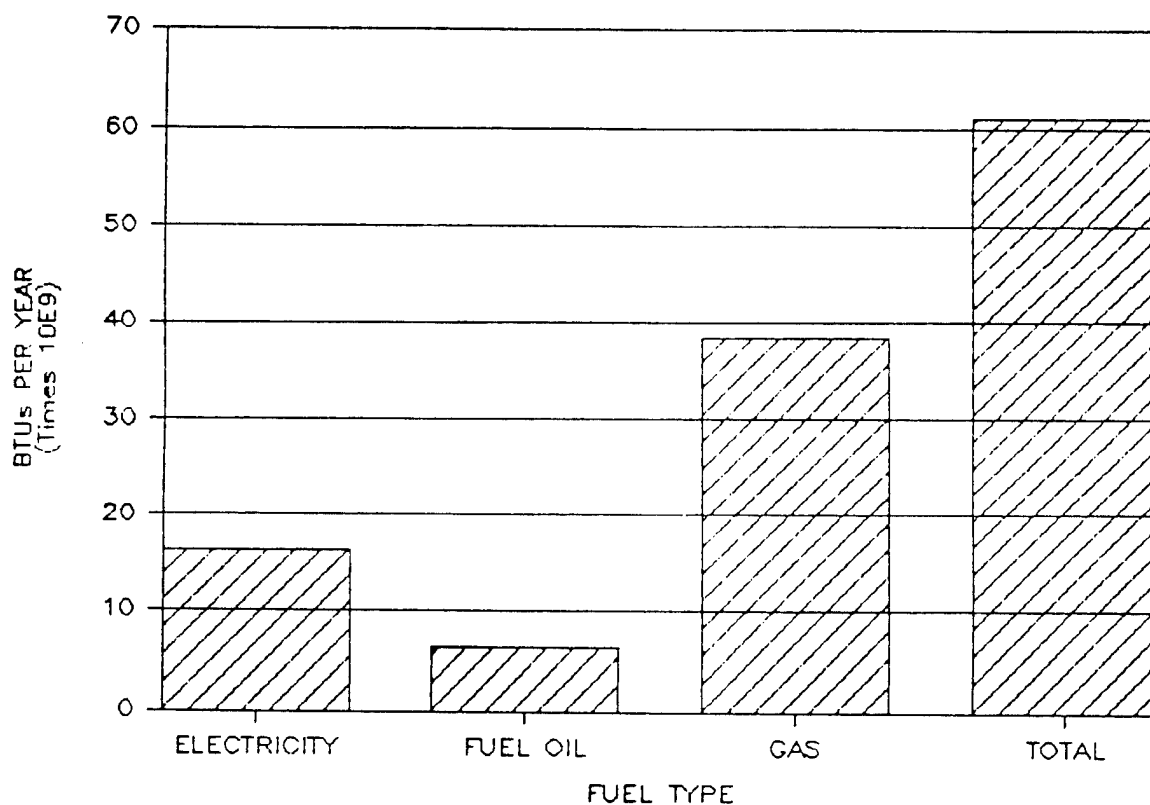
Table 1-5 lists all ECOs recommended for the detailed and walk-through buildings in order of SIR. As indicated, the total installed cost is estimated to be \$261,975 with a total annual savings of \$110,880 for a payback of 2.4 years.

**I.E.S.**

Mechanical and Electrical Engineers  
Chapel Hill, North Carolina

Figure 1-1.

### TOTAL ANNUAL ENERGY CONSUMPTION OF DETAILED BUILDINGS BASED ON BLAST ANALYSIS



#### Buildings Included in Detailed Audit

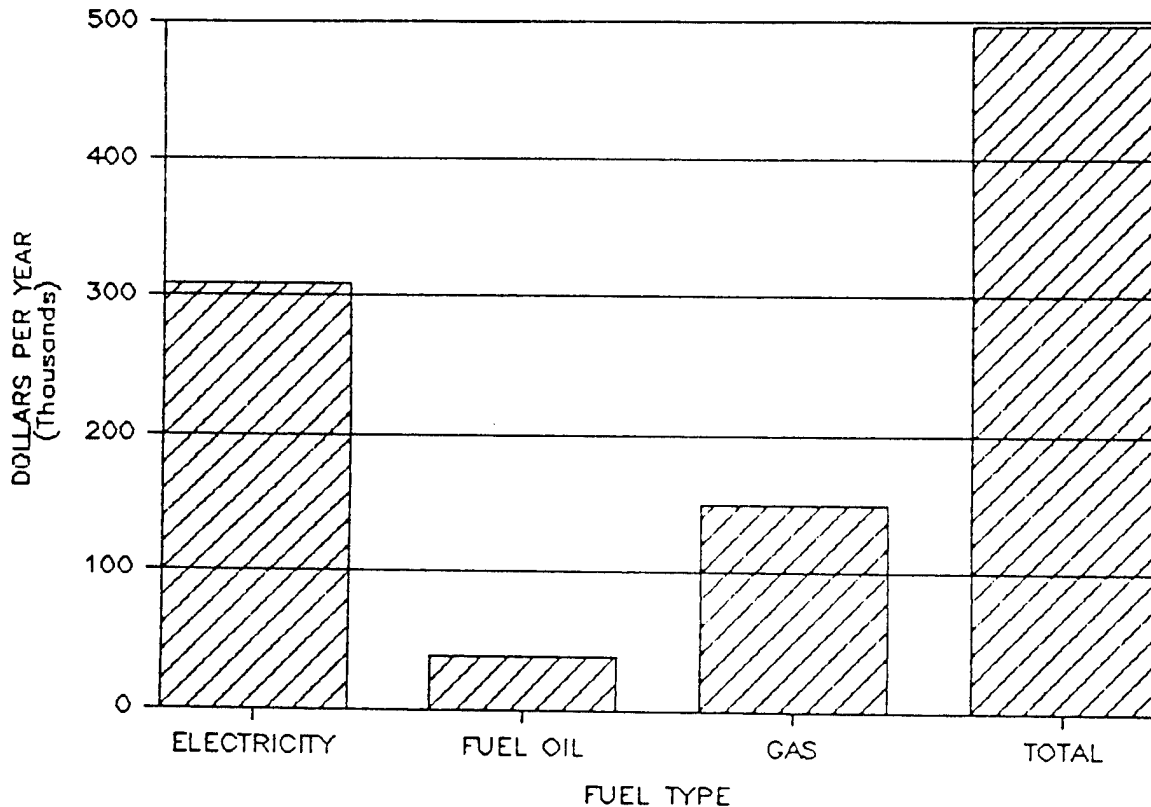
Building	Sq ft	Building	Sq ft
C-4122	4,850	O-9013	4,800
C-4422	4,850	P-3042	7,857
C-6432	4,850	I-1242	3,168
C-8344	4,850	4-1437	7,500
C-8750	5,050	A-3275	5,608
C-9349	5,050	AT-4622	2,800
C-7236	4,850	AT-4632	2,800
D-2626	11,313	AT-4686	2,800
D-3404	9,346	MT-6115	2,375
H-5718	14,920	8T-3849	13,400

**I.E.S.**

Mechanical and Electrical Engineers  
Chapel Hill, North Carolina

Figure 1-2.

**CALCULATED ANNUAL ENERGY COST 1987  
OF DETAILED BUILDINGS  
BASED ON BLAST ANALYSIS**



Buildings Included in Detailed Audit

Building	Sq ft	Building	Sq ft
C-4122	4,850	O-9013	4,800
C-4422	4,850	P-3042	7,857
C-6432	4,850	I-1242	3,168
C-8344	4,850	4-1437	7,500
C-8750	5,050	A-3275	5,608
C-9349	5,050	AT-4622	2,800
C-7236	4,850	AT-4632	2,800
D-2626	11,313	AT-4686	2,800
D-3404	9,346	MT-6115	2,375
H-5718	14,920	8T-3849	13,400

Table 1-2. Estimated Building Energy Consumption and Cost

Building	KWH	KW	Electricity		Fuel Oil		THERMS	GAS		\$	MBTU	TOTAL
			MBTU	Cost	GAL	MBTU		MBTU	\$			
C-4122	361236	113.3	1232.9	20244	0	0.0	0	15063	1506.3	5634	2739.2	25877
C-4422	324905	110.4	1108.9	18793	0	0.0	0	18287	1828.7	6839	2937.6	25633
C-6432	343246	112.9	1171.5	19597	0	0.0	0	17541	1754.1	6560	2925.6	26158
C-8344	336947	110.8	1150.0	19230	0	0.0	0	15119	1511.9	5655	2661.9	24884
C-8750	306680	105.8	1046.7	17846	0	0.0	0	19753	1975.3	7388	3022.0	25234
C-9349	311691	106.2	1063.8	18045	0	0.0	0	19686	1968.6	7363	3032.4	25408
C-7236	297158	76.2	1014.2	15481	0	0.0	0	31448	3144.8	11762	4159.0	27243
D-2626	267682	81.4	913.6	14824	0	0.0	0	48679	4867.9	18206	5781.5	33030
D-3404	247612	51.9	845.1	12100	0	0.0	0	29206	2920.6	10923	3765.7	23023
H-5718	761764	217.5	2599.9	41207	0	0.0	0	59887	5988.7	22398	8588.6	63604
O-9013	54439	39.4	185.8	4593	1665	231.0	1365	1651	165.1	617	581.9	6575
P-3042	139672	27.4	476.7	6693	10917	1514.2	8949	12020	1202.0	5289	3192.9	20931
I-1242	212716	106.6	726.0	24147	11576	1605.6	9489	0	0.0	0	2331.6	33637
4-1437	235130	100.0	802.5	23612	0	0.0	0	35371	3537.1	13229	4339.6	36841
A-3275	162028	41.9	553.0	11626	0	0.0	0	17000	1700.0	7480	2253.0	19106
AT-4622	65280	38.3	222.8	8377	0	0.0	0	10282	1028.2	4524	1251.0	12901
AT-4632	63493	37.8	216.7	8242	0	0.0	0	9217	921.7	4055	1138.4	12297
AT-4686	63375	37.8	216.3	8239	0	0.0	0	9671	967.1	4255	1183.4	12494
MT-6115	60973	36.7	208.1	7983	0	0.0	0	9223	922.3	4058	1130.4	12041
8T-3849	162291	39.9	553.9	8337	22433	3111.5	18389	4708	470.8	2072	4136.2	28798
4778318	1592.5	16308.4	309218	46592	6462.3	38192	383812	38381.2	148306	61151.9	495716	

Table 1-3. Sample ECO Checklist

FACILITY: Fort Bragg, NC

ENERGY ANALYSIS CHECKLIST, page 1 of 6

Building No: 4122

Date collected: \_\_\_\_\_

IES Inc., Chapel Hill, NC

ENERGY CONSERVATION OPPORTUNITIES (ECOs)

A. Heating, ventilating, and air conditioning

	YES	NO	EXPLANATION
1. Night setback/setup, shut off AHUs when possible		X	E EMCS
2. Reduce OA intake when air must be heated or cooled before use.		X	E already at minimum
3. Reduce supply and/or exhaust air flows		X	E already at minimum
4. Shut off/reduce speed of room fan coils		X	NA no fan coil units
5. Shut off/reduce stairwell or vestibule heating		X	NA vestibule not heated
6. Shut off unneeded circulating pumps		X	E no unneeded pumps
7. Reduce humidification to minimum requirements		X	NA no humidification exists
8. Reduce condenser water temperature		X	NA central chiller plant
9. Cycle fans and pumps		X	E EMCS
10. Reduce pumping flow		X	E already at minimum
11. Maintain authorized temperatures	X		See A-29
12. Use damper controls to shut off air to unoccupied areas			NA no unoccupied areas
13. Repair and maintain steam lines and traps		X	E good condition
14. Reset hot and cold deck temperatures based on areas with the greatest need		X	NA single zone system
15. Raise chilled water temperature		X	NA central chiller plant
16. Shed loads during peak electrical use periods		X	No available loads
17. Use OA for dry bulb economizer cycle	X		
18. Reduce reheating of cooled air		X	NA not a reheat system
19. Recover heating/cooling energy with energy recovery units	X		See G-3 and G-4
20. Reduce chilled water circulated during light cooling loads		X	NCE small system

E - existing

NCE - not cost effective

NA - not applicable/does not exist/not appropriate

FACILITY: Fort Bragg, NC

Building No: 4122

Date collected: \_\_\_\_\_

ENERGY ANALYSIS CHECKLIST, page 2 of 6

IES Inc., Chapel Hill, NC

ENERGY CONSERVATION OPPORTUNITIES (ECOs)

EXPLANATION

YES NO

A. Heating, ventilating, and air conditioning (continued)

21. Install minimum sized motor to meet loads  
22. Install infrared heating systems  
23. Convert to variable air volume system  
24. Common manifold of chillers  
25. Insulate ducts and piping  
26. Eliminate simultaneous heating and cooling

27. Clean coils  
28. Maintain filters  
29. Repair and/or maintain AHU controls  
30. Water treatment or prevent tube fouling  
31. Multispd/variable spd cooling tower fans  
32. Provide a separate cooling system  
33. Provide return air ductwork  
34. Reduce leakage of SA at AHU  
35. Reduce static pressure  
36. Install destratification fans  
37. Balance airflows  
38. Install make-up air systems in kitchen

39. Use thermal storage systems  
40. Shut off exhaust systems when not in use  
41. Install computerized energy monitoring and control system

E already minimum size	X			E already minimum size
NCE efficient system exists	X			NCE efficient system exists
NCE small system	X			NCE small system
NA central chiller plant	X			NA central chiller plant
E insulation exists	X			E insulation exists
E no simultaneous heating and cooling	X			E no simultaneous heating and cooling
See maintenance items				See maintenance items
See maintenance items				See maintenance items
NA central boiler/chiller plant	X			NA central boiler/chiller plant
NA central chiller plant	X			NA central chiller plant
NA no areas with diff. schedule	X			NA no areas with diff. schedule
E system has return ducts	X			E system has return ducts
E does not leak	X			E does not leak
E already at minimum	X			E already at minimum
E dining room has ceiling fans	X			E dining room has ceiling fans
E system is balanced	X			E system is balanced
E exhaust has integral make-up	X			E exhaust has integral make-up
NCE small system	X			NCE small system
E systems are shut off between meals	X			E systems are shut off between meals
E planned project	X			E planned project

FACILITY: Fort Bragg, NC

ENERGY ANALYSIS CHECKLIST, page 3 of 6

Building No: 4122

Date collected: \_\_\_\_\_

IES Inc., Chapel Hill, NC

ENERGY CONSERVATION OPPORTUNITIES (ECOs)

EXPLANATION

NO

YES

B. Boiler plant

1. Reduce steam distribution pressure
2. Increase boiler efficiency
3. Repair, replace or install condensate return system.
4. Insulate boiler and/or piping
5. Install boiler economizer
6. Install air pre-heater
7. Check boiler water chemistry program.
8. Clean boiler tubes
9. Blowdown controls
10. Modify boiler controls
11. Install smaller boiler

X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant
X	NA central boiler plant

C. Lighting

1. Shut off lights when not needed
2. Reduce lighting levels
3. Revise cleaning schedules
4. Convert to energy efficient systems

X	E lights are off between meals
X	E already at minimum
X	E fixtures are clean
X	Dining hall

FACILITY: Fort Bragg, NC

Building No: 4122

Date collected:

ENERGY ANALYSIS CHECKLIST, page 4 of 6

IES Inc., Chapel Hill, NC

## ENERGY CONSERVATION OPPORTUNITIES (ECOs)

#### D. Building Envelope

1. Reduce infiltration by caulking and weatherstripping
2. Install double pane windows
3. Install roof insulation
4. Install loading dock seals
5. Install vestibules on entrances
6. Install solar shading, films, screening, curtains, for blinds
7. Install insulation in walls
8. Install floor insulation
9. Install plastic strips at personnel entrances
10. Install insulating panels over windows

X	E double pane windows recently installed
X	E retrofit insulation installed
X	NCE usage too low
X	E main entrance is through barracks
X	E tinted windows
X	E planned project
X	NA floor over hot pipe chase
X	NA not practical for kitchen
X	E top panels are insulated

### E. Electrical Equipment

1. Use emergency generator to reduce peak demand
2. Shed/cycle elect loads to reduce peak demand
3. Convert to energy efficient motors
4. Improve power factor
5. Shut off electric equipment when not needed

X	NA no emergency generator
X	NA no loads which can be cycled
X	NCE small motors
X	NA no current penalty charge
X	E personnel turn off unneeded equipment

FACILITY: Fort Bragg, NC

ENERGY ANALYSIS CHECKLIST, page 5 of 6

Building No: 4122

Date collected: \_\_\_\_\_

IES Inc., Chapel Hill, NC

-----  
ENERGY CONSERVATION OPPORTUNITIES (ECOs)  
-----

F. Plumbing

1. Reduce domestic hot water temperature
2. Repair and/or install water heater and hot water piping insulation
3. Install flow restrictors
4. Install faucets which automatically shut off water flow
5. Decentralize hot water heating
6. Use booster heaters on dishwashing equipment
7. Recover heat from hot wastewater
8. Install heat pump water heaters to provide hot water and cool the dining area
9. Improve water heater efficiency
10. Shut off water heater during unoccupied period

YES	NO	EXPLANATION
---	X	E already at minimum
---	X	E good condition
---	X	NA not practical for kitchen
---	X	NA not practical for kitchen
---	X	NA kitchen uses majority of DHW
X	---	Convert to steam
X	---	
X	---	
---	X	E good efficiency
---	X	NA needed for barracks

FACILITY: Fort Bragg, NC

ENERGY ANALYSIS CP-CKLIST, page 6 of 6

Building No: 4122

Date collected: \_\_\_\_\_

IES Inc., Chapel Hill, NC

ENERGY CONSERVATION OPPORTUNITIES (ECOs)

G. Kitchen

1. Shut off range hood exhaust when possible and install dampers
2. Shut off equipment and appliances whenever possible
3. Recover heat from refrigeration equipment
4. Install exhaust heat recovery systems
5. Install automatic pilot lights
6. Install low temperature chemical rinse dishwashing equipment
7. Optimize kitchen operational procedures
8. Operate dishwashers only with full loads
9. Preheat only the equipment that will be used
10. Preheat equipment just before using
11. Avoid use of hot water for dish scraping
12. Clean refrigeration coils
13. Cook with lids in place
14. Thaw frozen food in refrigerated compartments
15. Direct cooling fans away from cooking equipment
16. Use kitchen exhaust only when needed
17. Clean exhaust hood grease filters
18. Provide direct exhaust hood make-up air supply
19. Match pots to burner size so that pots completely cover burner
20. Steam vegetables in lieu of boiling when possible
21. De-energize booster water heaters at night
22. Use microwave cooking equipment in lieu of conventional equipment when possible

YES	NO	EXPLANATION
	X	E personnel turn off hoods
	X	E personnel turn off unneeded equipment
	X	E electric equipment
	X	E see Chapter 1
	X	E dishwashers used only for full loads
	X	E already done
	X	E already done
	X	E used only when necessary
	X	E coils are clean
	X	E lids are used
	X	NA no ceiling fans in kitchen
	X	E personnel turn off between meals
	X	E filters were clean
	X	E direct supply exists
	X	E large pots are used
	X	E steamer is used when possible
	X	E units are turned off at night
X		

---

Table 1-4. Order of Computer Runs to Account for Interaction

- 1) base case as observed during field investigation  
(including planned projects)
  - 2) implement envelope ECOs
  - 3) implement lighting ECOs
  - 4) implement ECOs to miscellaneous equipment
  - 5) implement HVAC ECOs
-

Table 1-5, Recommended EC0s, Ranked by SIR, All Buildings

ECO AND DESCRIPTION	INSTALLED COST	FIRST YEAR \$ SAVINGS ENERGY	NON-ENERGY	PAYBACK YRS	SIR	ANNUAL SAVINGS		
						ELEC MBTU	GAS MBTU	#2 OIL MBTU
B-8-T-3849	201	1918	-130	0.1	84.25	0.0	0.0	324.6
A-29-AT-4686	153	332	0	0.5	23.14	0.0	75.5	0.0
F-6-4-1437	3506	254	6026	0.6	16.98	113.9	-175.2	0.0
C-4-AT-4622	52	53	52	0.5	14.55	8.2	-2.9	0.0
C-4-AT-4632	52	51	52	0.5	14.28	8.2	-3.2	0.0
A-1-A-3275	1266.0	1334.0	-37.0	1.0	10.63	20.0	270.0	0.0
F-6-C-4424	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-4122	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-4120	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-8339	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-3321	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-7433	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-3027	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-6432	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-3020	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-5528	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-8541	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-4426	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-8750	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-4422	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-4125	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-8344	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-4428	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-5725	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-6525	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-9349	3030	530	2655	1.0	9.18	122.6	-188.7	0.0
F-6-C-7634	3030	530	2655	1.0	9.17	122.6	-188.7	0.0
D-1-0-9013	307	137	0	2.2	8.86	0.0	0.0	23.2
C-4-P-3042	90	51	10	1.5	8.57	5.1	0.0	0.0
A-1-0-9013	506	274	0	1.8	7.24	0.0	0.0	46.4
C-4-8T-3849	104	66	0	1.6	6.46	11.7	0.0	-8.8
D-1-P-3042	221	219	0	1.0	4.82	1.0	0.0	35.3
A-1-MT-6115	786	349	-25	2.4	4.28	6.3	67.9	0.0
D-1-C-6726	90	65	0	1.4	3.72	1.2	14.1	0.0

Table 1-5, Recommended ECOs, Ranked by SIR, All Buildings (Continued)

ECO AND DESCRIPTION	INSTALLED COST	FIRST YEAR \$ SAVINGS	PAYBACK YRS	SIR	ANNUAL SAVINGS		
					ELEC MBTU	GAS MBTU	#2 OIL MBTU
D-1-C-8438	90	65	0	3.72	1.2	14.1	0.0
D-1-C-7236	90	65	0	3.72	1.2	14.1	0.0
D-7-8T-3849	1730	669	0	3.63	-0.6	0.0	114.3
D-1-C-5528	90	63	0	3.41	2.9	8.9	0.0
D-1-C-4426	90	63	0	3.41	2.9	8.9	0.0
D-1-C-5725	90	63	0	3.41	2.9	8.9	0.0
C-4-C-4122	2759	580	238	3.41	65.6	-21.8	0.0
D-1-C-7634	90	63	0	3.41	2.9	8.9	0.0
D-1-C-4428	90	63	0	3.41	2.9	8.9	0.0
D-1-C-3020	90	63	0	3.41	2.9	8.9	0.0
D-1-C-8339	90	63	0	3.41	2.9	8.9	0.0
D-1-C-6525	90	63	0	3.41	2.9	8.9	0.0
D-1-C-4424	90	63	0	3.41	2.9	8.9	0.0
D-1-C-7433	90	63	0	3.41	2.9	8.9	0.0
D-1-C-4125	90	63	0	3.41	2.9	8.9	0.0
D-1-C-3321	90	63	0	3.41	2.9	8.9	0.0
D-1-C-3027	90	63	0	3.41	2.9	8.9	0.0
D-1-C-4120	90	63	0	3.41	2.9	8.9	0.0
F-2-AT-4622	218	64	0	3.14	0.0	14.6	0.0
C-4-0-9013	1341	249	90	3.02	27.7	0.0	-5.1
G-5-AT-4622	545	156	0	3.5	0.7	34.2	0.0
B-11-8T-3849	6374	2145	-130	2.99	0.0	0.0	363.0
G-5-AT-4686	545	153	0	2.96	0.8	33.4	0.0
D-3-8T-3849	5052	1551	0	2.94	-18.0	0.0	293.2
D-1-C-6432	90	52	0	2.93	1.4	10.1	0.0
D-7-MT-6115	618	162	0	2.88	-2.2	40.7	0.0
G-5-MT-6115	545	141	0	2.69	1.6	29.2	0.0
D-1-C-4122	90	47	0	2.67	1.0	9.8	0.0
C-4-C-3020	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-6525	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-3027	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-7433	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-5725	2759	371	238	2.62	41.0	-11.4	0.0

Table 1-5, Recommended EC0s, Ranked by SIR, All Buildings (Continued)

ECO AND DESCRIPTION	INSTALLED COST	FIRST YEAR \$ SAVINGS ENERGY	NON-ENERGY PAYBACK YRS	SIR	ANNUAL SAVINGS		
					ELEC MBTU	GAS MBTU	#2 OIL MBTU
C-4-C-3321	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-4120	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-4428	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-8339	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-4125	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-4424	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-7634	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-4426	2759	371	238	2.62	41.0	-11.4	0.0
C-4-C-5528	2759	371	238	2.62	41.0	-11.4	0.0
A-17-C-6432	612	180	-16	2.58	17.9	0.0	0.0
C-4-C-4422	2759	300	238	2.42	31.0	-3.3	0.0
C-4-C-8541	2759	293	238	2.40	30.1	-2.7	0.0
C-4-C-8344	2759	293	238	2.40	30.1	-2.7	0.0
A-17-C-4122	612	167	-16	2.37	16.6	0.0	0.0
C-4-C-8750	3471	310	306	2.19	32.9	-5.8	0.0
C-4-C-9349	3471	307	306	2.17	32.8	-6.2	0.0
A-17-C-8541	612	153	-16	2.15	15.2	0.0	0.0
A-17-C-8344	612	153	-16	2.15	15.2	0.0	0.0
C-4-C-7236	2759	232	238	2.11	24.4	-3.6	0.0
C-4-C-8438	2759	232	238	2.11	24.4	-3.6	0.0
C-4-C-6726	2759	232	238	2.11	24.4	-3.6	0.0
C-4-C-6432	2759	233	238	2.03	26.5	-9.1	0.0
A-17-C-4426	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-3027	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-4428	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-3321	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-7634	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-4120	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-6525	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-5528	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-3020	612	143	-16	1.99	14.2	0.0	0.0
A-17-C-4125	612	143	-16	1.99	14.2	0.0	0.0

Table 1-5, Recommended EC0s, Ranked by SIR, All Buildings (Continued)

ECO AND DESCRIPTION	INSTALLED COST	ENERGY	\$ SAVINGS NON-ENERGY	PAYBACK YRS	SIR	ANNUAL SAVINGS		
						ELEC MBTU	GAS MBTU	#2 OIL MBTU
A-17-C-7433	612	143	-16	4.8	1.99	14.2	0.0	0.0
A-17-C-8339	612	143	-16	4.8	1.99	14.2	0.0	0.0
A-17-C-5725	612	143	-16	4.8	1.99	14.2	0.0	0.0
A-17-C-4424	612	143	-16	4.8	1.99	14.2	0.0	0.0
D-1-C-8344	90	32	0	2.8	1.83	0.7	6.7	0.0
D-1-C-8541	90	32	0	2.8	1.83	0.7	6.7	0.0
D-1-C-4422	90	30	0	3.0	1.75	0.5	6.8	0.0
D-9-8T-3849	7469	1329	0	5.6	1.68	-4.4	0.0	232.4
A-17-C-6726	612	123	-16	5.7	1.67	12.2	0.0	0.0
A-17-C-7236	612	123	-16	5.7	1.67	12.2	0.0	0.0
A-17-C-8438	612	123	-16	5.7	1.67	12.2	0.0	0.0
D-1-AT-4686	339	103	0	3.3	1.62	0.0	23.5	0.0
D-1-MT-6115	441	117	0	3.8	1.42	-0.2	27.0	0.0
D-1-AT-4632	339	89	0	3.8	1.40	0.1	20.1	0.0
D-1-8T-3849	624	177	0	3.5	1.39	0.0	0.0	30.0
D-1-AT-4622	339	86	0	3.9	1.34	0.1	19.3	0.0
A-29-C-6432	2823	291	0	9.7	1.27	16.0	34.8	0.0
D-1-C-9349	180	42	0	4.3	1.21	0.7	9.4	0.0
D-1-C-8750	180	40	0	4.5	1.16	0.6	9.1	0.0
A-29-H-5718	1375	163	0	8.4	1.15	16.2	0.0	0.0
A-29-C-3321	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-5725	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-6525	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-3027	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-3020	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-4120	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-8339	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-4125	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-4424	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-4426	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-7433	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-4428	2823	265	0	10.7	1.12	16.2	27.3	0.0

Table 1-5, Recommended EC0s, Ranked by SIR, All Buildings (Continued)

EC0 AND DESCRIPTION	INSTALLED COST	ENERGY SAVINGS \$	FIRST YEAR NON-ENERGY	PAYBACK YRS	SIR	ANNUAL SAVINGS		
						ELEC MBTU	GAS MBTU	#2 OIL MBTU
A-29-C-7634	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-5528	2823	265	0	10.7	1.12	16.2	27.3	0.0
A-29-C-8750	2823	254	0	11.1	1.09	14.8	28.1	0.0
A-29-C-4422	2823	262	0	10.8	1.09	16.8	24.7	0.0
A-29-C-9349	2926	252	0	11.6	1.04	14.6	27.9	0.0
A-17-C-4422	612	82	-16	9.3	1.02	8.1	0.0	0.0
A-1-8T-3849	11908	1409	-74	8.9	1.01	32.1	0.0	183.6
A-29-C-8344	2823	245	0	11.5	1.01	16.0	22.3	0.0
A-29-C-8541	2823	245	0	11.5	1.01	16.0	22.3	0.0
A-29-C-6726	2823	233	0	12.1	1.00	13.4	26.2	0.0
A-29-C-8438	2823	233	0	12.1	1.00	13.4	26.2	0.0
A-29-C-7236	2823	233	0	12.1	1.00	13.4	26.2	0.0
A-29-C-4122	2823	242	0	11.7	1.00	15.7	22.4	0.0
T O T A L S	261975	3942	67085	3.7		4434.2	-2841.8	1632.1

### 1.4.3 ECOs Considered but not Recommended

Table 1-6 is a list of typical ECOs which were analyzed but were not found to be cost effective.

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Table 1-6. Typical ECOs Not Recommended

<u>ECO</u>	<u>Title</u>	<u>Reason Rejected</u>
F-7	Waste Water Heat Recovery	SIR < 1.0
F-8	Heat Pump Water Heater	SIR < 1.0
G-3	Refrigerant Heat Recovery	SIR < 1.0
G-4	Exhaust Heat Recovery	SIR < 1.0
D-1	Double Pane Replacement Windows	SIR < 1.0
A-32	Replace HVAC System	SIR < 1.0

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### 1.5 Energy and Cost Savings

Table 1-7 summarizes the ECO cost and dollar savings by type of building. As noted, the total cost of implementation is \$261,975, with an energy savings of \$43,795 and a non-energy savings of \$67,085, for a payback of 2.4 years.

Table 1-8 summarizes the total annual energy cost and consumption by fuel type for the detailed buildings before and after energy conservation. Figures 1-3 and 1-4 also show energy cost and consumption before and after energy conservation for the detailed buildings.

Table 1-9 shows the energy consumption and cost per meal and per square foot for the detailed building. The consumption and cost per square foot data was extrapolated to similar walk-thru buildings to form Table 1-10. Figure 1-5 combines the calculated energy cost for the detailed buildings and the extrapolated cost for the walk-thru buildings to show the total energy cost before and after energy conservation.

### 1.6 Projects Developed

Table 1-11 summarizes the projects developed. Many ECOs listed in the ECO summary table (Table 1-5) have not been programmed; thus the totals for Table 1-9 are less than Table 1-5. These ECOs were not programmed because it was discovered at the Interim Presentation that they have been included in other ongoing projects or are no longer applicable.

Table 1-7, Recommended EC0s, By Building Category

Building Type & Category	INSTALLED COST	\$ SAVINGS ENERGY	NON-ENERGY	PAYBACK YRS	SAVINGS		
					ELEC MBTU	GAS MBTU	#2 OIL MBTU
Category 1, Type 64, C Buildings	158338	23264	48909	2.2	3342.0	-2786.0	0.0
Category 2, Type 64A, C Buildings	18628	2506	5754	2.3	369.2	-324.8	3264.2
Category 3, Type 121, C Buildings	9504	1134	2961	2.3	170.9	-157.3	0.0
Category 4, Type 121, C Buildings	9607	1131	2961	2.3	170.7	-157.6	0.0
Category 5, Type 64, C Buildings	18852	1959	666	7.2	153.6	110.1	0.0
Category 8, H Buildings	1375	163	0	8.4	16.2	0.0	0.0
Category 9, O Buildings	2154	660	90	2.9	27.7	0.0	64.5
Category 10, P Buildings	311	270	10	1.1	6.1	0.0	35.3
Category 12, (4) Buildings	3506	254	6026	0.6	113.8	-175.2	0.0
Temporary Buildings, Types (AT, MT, 8T)	38434	11120	-255	3.5	44.0	379.0	1532.3
Building A-1-A-3275	1266.0	1334.0	-37.0	1.0	20.0	270.0	0.0
T O T A L S	261975	43795	67085	2.4	4434.2	-2841.8	4896.3

Table 1-8. Total Energy Cost and Consumption, Before and After Conservation (Detailed Buildings)

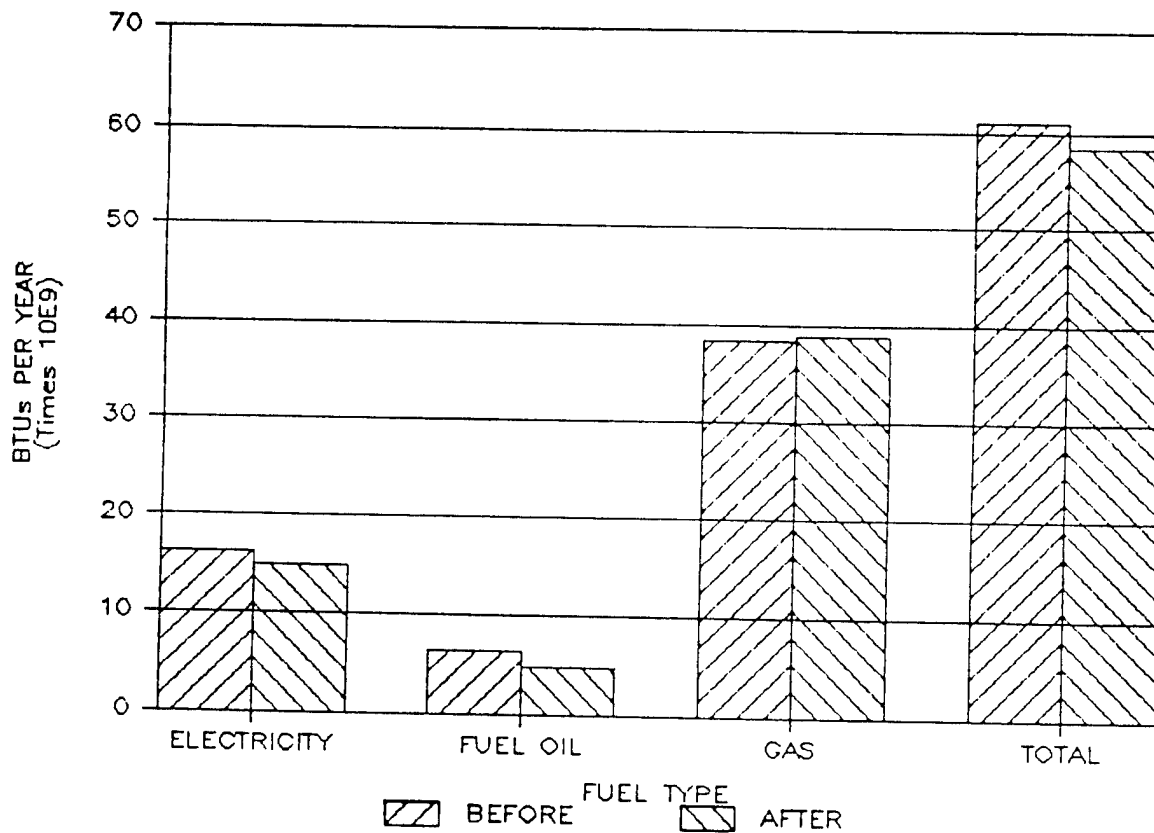
	Before Conservation				After Conservation				Total % Reduction
	Gas	Oil	Elec	Total	Gas	Oil	Elec	Total	
\$ Cost	148,306	38,192	309,218	495,716	149,590	28,546	271,590	449,726	10.2
Consumption (MBTUs)	38,381.2	6,462.3	16,308.4	61,151.9	38,839.4	4,830.2	14,917.8	58,587.4	4.4

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Chapel Hill, North Carolina

Figure 1-3.

## ENERGY CONSUMPTION BEFORE & AFTER OF DETAILED BUILDINGS



### Buildings Included in Detailed Audit

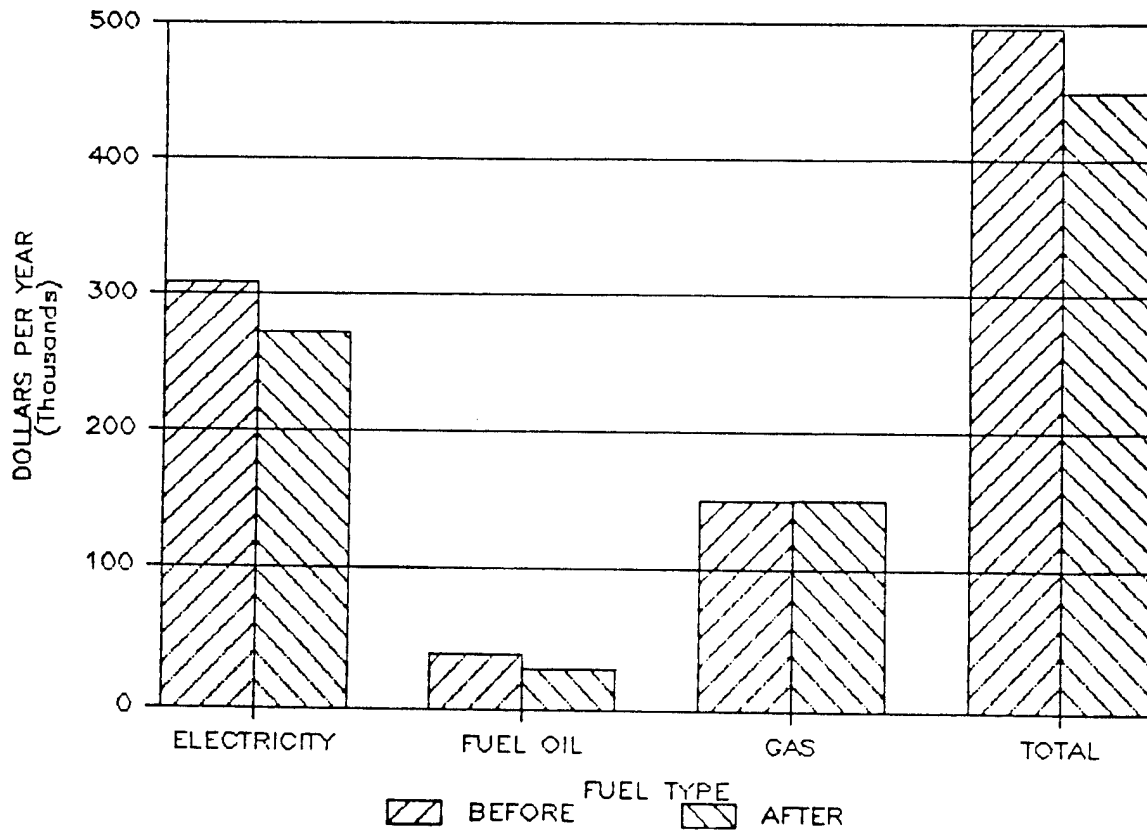
Building	Sq ft	Building	Sq ft
C-4122	4,850	O-9013	4,800
C-4422	4,850	P-3042	7,857
C-6432	4,850	I-1242	3,168
C-8344	4,850	4-1437	7,500
C-8750	5,050	A-3275	5,608
C-9349	5,050	AT-4622	2,800
C-7236	4,850	AT-4632	2,800
D-2626	11,313	AT-4686	2,800
D-3404	9,346	MT-6115	2,375
H-5718	14,920	8T-3849	13,400

**I.E.S.**

Mechanical and Electrical Engineers  
Chapel Hill, North Carolina

Figure 1-4.

### ENERGY COST BEFORE & AFTER OF DETAILED BUILDINGS



#### Buildings Included in Detailed Audit

Building	Sq ft	Building	Sq ft
C-4122	4,850	O-9013	4,800
C-4422	4,850	P-3042	7,857
C-6432	4,850	I-1242	3,168
C-8344	4,850	4-1437	7,500
C-8750	5,050	A-3275	5,608
C-9349	5,050	AT-4622	2,800
C-7236	4,850	AT-4632	2,800
D-2626	11,313	AT-4686	2,800
D-3404	9,346	MT-6115	2,375
H-5718	14,920	8T-3849	13,400

Table 1-9. Energy Summary Data, Detailed Buildings

BUILDING	AREA	MBTU	COST	BEFORE CONSERVATION				AFTER CONSERVATION			
				MEALS/ YEAR	MBTU/ SQ FT	MBTU/ MEAL	COST/ SQ FT	MBTU/ SQ FT	MBTU/ MEAL	COST/ SQ FT	COST/ MEAL
C-4122	4,850	2,739.2	\$25,877	234,000	0.5648	0.0117	\$5.34	2,696.0	0.5559	\$21,428	\$4.42
C-4422	4,850	2,937.6	\$25,633	234,000	0.6057	0.0126	\$5.29	2,919.1	0.6019	\$21,536	\$4.44
C-6432	4,850	2,925.6	\$26,158	234,000	0.6032	0.0125	\$5.39	2,894.1	0.5967	\$21,979	\$4.53
C-8344	4,850	2,661.9	\$24,884	234,000	0.5488	0.0114	\$5.13	2,639.7	0.5443	\$20,738	\$4.28
C-8750	5,050	3,022.0	\$25,234	234,000	0.5984	0.0129	\$5.00	3,008.4	0.5957	\$21,139	\$4.19
C-9349	5,050	3,032.4	\$25,408	234,000	0.6005	0.0130	\$5.03	3,019.3	0.5979	\$21,316	\$4.22
C-7236	4,850	4,159.0	\$27,243	234,000	0.8575	0.0178	\$5.62	4,071.1	0.8394	\$26,352	\$5.43
D-2626	11,313	5,781.5	\$33,030	352,300	0.5110	0.0164	\$2.92	5,781.5	0.5110	\$33,030	\$2.92
D-3404	9,346	3,765.7	\$23,023	255,500	0.4029	0.0147	\$2.46	3,765.7	0.4029	\$23,023	\$2.46
H-5718	14,920	8,588.6	\$63,604	730,000	0.5756	0.0118	\$4.26	8,572.4	0.5746	\$63,441	\$4.25
O-9013	4,800	581.9	\$6,575	16,640	0.1212	0.0350	\$1.37	489.7	0.1020	\$5,825	\$1.21
P-3042	7,857	3,192.9	\$20,931	100,375	0.4064	0.0318	\$2.66	3,151.5	0.4011	\$20,651	\$2.63
I-1242	3,168	2,331.6	\$33,637	240,900	0.7360	0.0097	\$10.62	2,331.6	0.7360	\$33,637	\$10.62
A-1437	7,500	4,339.6	\$36,841	236,600	0.5786	0.0183	\$4.91	4,400.9	0.5868	\$30,561	\$4.07
A-3275	5,608	2,253.0	\$19,106	164,250	0.4017	0.0137	\$3.41	1,963.0	0.3500	\$17,772	\$3.17
AT-4622	2,800	1,251.0	\$12,901	73,000	0.4468	0.0171	\$4.61	1,176.8	0.4203	\$12,490	\$4.46
AT-4632	2,800	1,138.4	\$12,297	73,000	0.4066	0.0156	\$4.39	1,113.2	0.3976	\$12,105	\$4.32
AT-4686	2,800	1,183.4	\$12,494	73,000	0.4226	0.0162	\$4.46	1,050.2	0.3751	\$11,906	\$4.25
MT-6115	2,375	1,130.4	\$12,041	73,000	0.4760	0.0155	\$5.07	960.1	0.4043	\$11,272	\$4.75
8T-3849	13,400	4,136.2	\$28,798	119,600	0.3087	0.0346	\$2.15	2,583.1	0.1928	\$19,868	\$1.48
TOTALS	123,037	61,151.9	\$495,715	4,146,165	10.1731	0.3422	\$90.09	58,587.4	9.7862	\$450,069	\$82.11
									0.3153		\$2.68

Table 1-10. Extrapolated Energy Data, Walk-thru Buildings

BUILDING	AREA	BEFORE CONSERVATION			AFTER CONSERVATION		
		MBTU	COST	MBTU/ SQ FT	COST/ SQ FT	MBTU	COST
C-3020	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-3027	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-3321	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-4120	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-4125	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-4424	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-4426	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-4428	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-5528	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-5725	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-6525	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-7433	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-7634	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-8339	4,850	2,867.5	\$25,889	0.5912	\$5.34	2,836.4	\$21,648
C-8541	4,850	2,661.9	\$24,884	0.5488	\$5.13	2,639.7	\$20,738
C-6726	4,850	4,159.0	\$27,243	0.8575	\$5.62	4,071.1	\$26,352
C-8438	4,850	4,159.0	\$27,243	0.8575	\$5.62	4,071.1	\$26,352
D-2105	11,313	5,781.5	\$33,030	0.5110	\$2.92	5,781.5	\$33,030
D-3039	11,313	5,781.5	\$33,030	0.5110	\$2.92	5,781.5	\$33,030
D-3055	11,313	5,781.5	\$33,030	0.5110	\$2.92	5,781.5	\$33,030
H-4842	14,920	8,588.6	\$63,604	0.5756	\$4.26	8,572.4	\$63,441
2-1105	3,168	2,331.6	\$33,637	0.7360	\$10.62	2,331.6	\$33,637
2-1138	3,168	2,331.6	\$33,637	0.7360	\$10.62	2,331.6	\$33,637
TOTALS	137,645	81,721.2	\$671,789	14.1220	\$125.35	81,071.6	\$606,314
							13.9903
							\$111.88

Table 1-11. Project Summary Totals

ECO AND DESCRIPTION	TOTAL INSTALLED COST	TOTAL \$ SAVINGS ENERGY NON-ENERGY	TOTAL PAYBACK YRS	TOTAL SIR	TOTAL SAVINGS		
					ELEC MBTU	GAS MBTU	#2 OIL MBTU
Project # 1 Low Cost/No Cost ECO's	419	1982	0.2	42.02	0.0	14.6	324.6
Project # 2 Install Steam Booster Heaters	67136	11384	0.9	9.18	2688.5	-4137.9	0.0
Project # 3 Weatherstripping	1119	309	3.6	1.47	-0.1	70.6	0.0
Project # 4 Wall Insulation	618	162	3.8	2.88	-2.2	40.7	0.0
Project # 5 Fluorescent Lighting	69279	8676	4.7	2.55	957.1	-228.1	-13.9
Project # 6 Controls ECO's	2711	2289	1.2	8.49	26.3	413.4	46.4
Project # 7 Dry Bulb Economizers	13464	3106	4.9	1.96	308.4	0.0	0.0
GRAND TOTALS	154746*	27908	1.6		3978.0	-3826.7	357.1

Note: Projects #2-7 are assumed to be implemented in 1989; Project #1 in 1988.

\* Does not include ECOs which have been programmed or determined not applicable due to demolition subsequent to the initiation of this study.

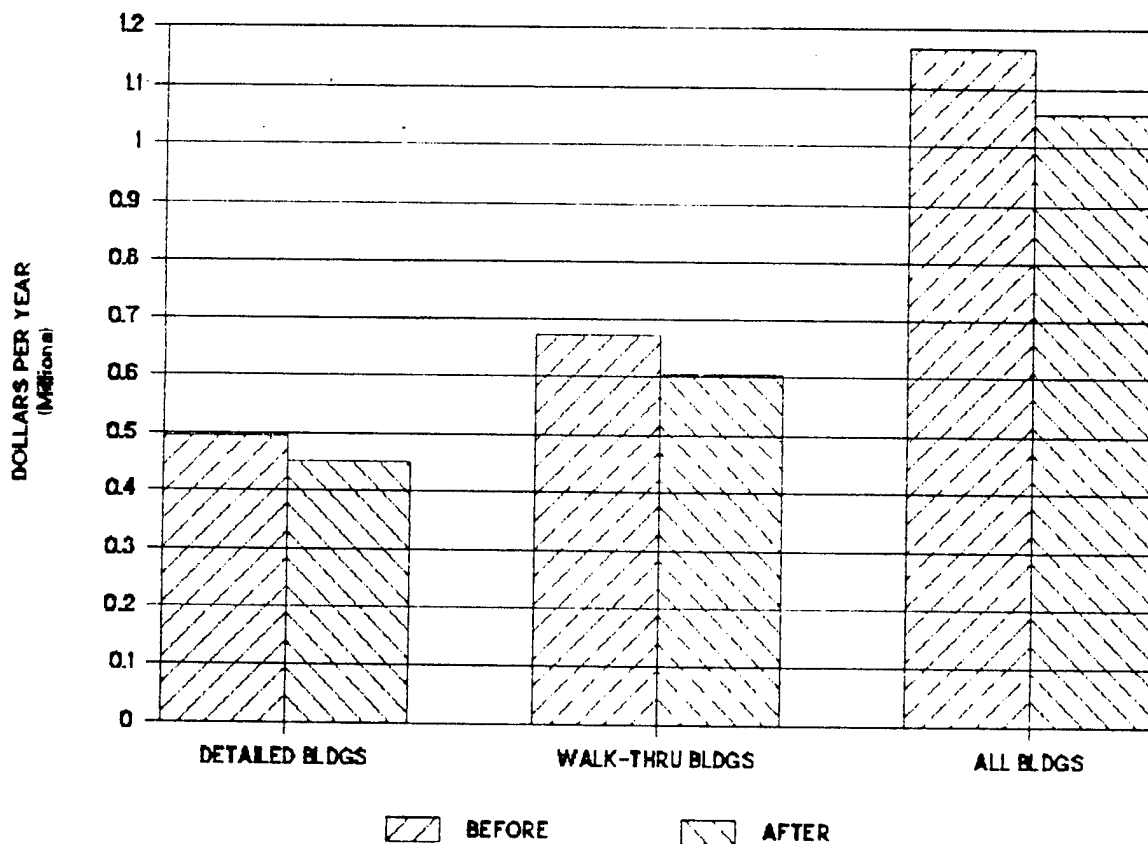


**I.E.S.**

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Chapel Hill, North Carolina

Figure 1-5.

### ENERGY COST BEFORE & AFTER (Includes All Buildings)



#### Notes

- 1) Data for Detailed Buildings was based on BLAST Analysis.
- 2) Data for Walk-thru Buildings was extrapolated for similar detailed buildings.

Project #1 consists of Low Cost/No Cost ECOs. These are ECOs which will be completed with DEH funds, scheduled for 1988.

Project #2 has been programmed as a QRIP project for 1989.

Projects #3-7 do not qualify for any of the funding categories listed in the SOW (ECIP, QRIP, PECIP, OSD/PIF). Programming documentation similar to QRIP documents was completed for these projects for 1989, at the request of base personnel. These projects will be funded under other military programs.